

US EPA ARCHIVE DOCUMENT



Surface Waters

Western Pilot Study:

Field Operations Manual for Wadeable Streams



Environmental Monitoring and
Assessment Program



**ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM-
SURFACE WATERS:**

**WESTERN PILOT STUDY
FIELD OPERATIONS MANUAL FOR
WADEABLE STREAMS**

Edited by

David V. Peck¹, James M. Lazorchak², and Donald J. Klemm²

¹ U.S. Environmental Protection Agency
Regional Ecology Branch
Western Ecology Division
National Health and Environmental Effects Research Laboratory
Corvallis, OR 97333

² U.S. Environmental Protection Agency
Ecosystems Research Branch
Ecological Exposure Research Division
National Exposure Research Laboratory
Cincinnati, OH 45268

NATIONAL HEALTH AND ENVIRONMENTAL EFFECTS RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

NATIONAL EXPOSURE RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

NOTICE

This document is a preliminary draft. It has not been formally released by the U.S. Environmental Protection Agency and should not at this stage be construed to represent Agency Policy. It is being circulated for comments on its technical merit and policy implications.

This work is in support of the Environmental Monitoring and Assessment Program (EMAP). Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The correct citation for this document is:

Peck, D.V., J.M. Lazorchak, and D.J. Klemm (editors). Unpublished draft.
Environmental Monitoring and Assessment Program -Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. EPA/XXX/X-XX/XXXX.
U.S. Environmental Protection Agency, Washington, D.C.

Section authors are listed on the following page. Complete addresses for authors are also provided in each section.

Section 1: J.M. Lazorchak¹, A.T. Herlihy², D.J. Klemm¹, and S.G. Paulsen³
Section 2: B.H. Hill¹, F.H. McCormick¹, J.M. Lazorchak¹, D.J. Klemm¹, and M. Cappaert⁴
Section 3: D.J. Klemm¹, B.H. Hill¹, F.H. McCormick¹, and M. Cappaert⁴
Section 4: A T. Herlihy²
Section 5: A T. Herlihy²
Section 6: P R. Kaufmann³
Section 7: P R. Kaufmann³

¹ U.S. EPA, National Exposure Research Laboratory, Cincinnati, OH 45628.

² Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97333.

³ U.S. EPA, National Health and Environmental Effects Research laboratory, Corvallis, OR 97333.

⁴ OAO Corp., Corvallis, OR 97333.

Section 8: B.H. Hill¹

Section 9: None

Section 10: None

Section 11: D.J. Klemm¹, J.M. Lazorchak¹, and P.A. Lewis^{1,4}

Section 12: F.H. McCormick¹ and R. M. Hughes⁵

Section 13: R.B. Yeardley, Jr.⁸, F.H. McCormick¹, R.M. Hughes⁶, and S.A. Peterson³

Section 14: A. T. Herlihy² and J.M. Lazorchak¹

Section 15: J.M. Lazorchak¹

⁵ Dynamac International, Inc., Corvallis, OR 97333.

FOREWORD

The National Exposure Research Laboratory (NERL) and the National Health and Environmental Effects Research Laboratory (NHEERL) provide scientific understanding, information and assessment tools that will reduce and quantify the uncertainty in the Agency's exposure and risk assessments for all environmental stressors. Stressors include chemicals, biologicals, radiation, climate, and land and water use changes.

Research at NERL focuses on: (1) characterizing the sources of environmental stressors and the compartments of the environment in which they reside or move; (2) studying the pathways through environmental compartments that lead to exposure of receptors to stressors; (3) investigating intra- and inter compartmental stressor transfers and their transformations; and (4) studying and characterizing receptors and their activities as required to predict or measure stressor exposure. Research products from NERL provide effects researchers and risk assessors with information on stressor sources, pollutant transport and transformations and exposure, and state-of-the-science source-to-receptor predictive exposure models applicable at the appropriate temporal scales and site, watershed/regional and global scales. It also provides risk managers with receptor-back-to-source and stressor-back-to-cause analyses and evaluations of alternative mitigation, management or restoration strategies from an exposure perspective.

Ecological research at NHEERL contribute to improving hazard identification, dose-response assessments, and risk characterization at multiple spatial and temporal scales. Research products from NHEERL include improved assessment methods and improved approaches to interpreting the data acquired by these methods. Major uncertainties in assessing the effects on ecosystems resulting from exposure to environmental stressors are addressed through the development of the tools necessary for effective monitoring of ecosystems and their components, by mechanistic studies, and through modeling.

To accomplish its mission, NERL conducts fundamental and applied research designed to:

1. Characterize air, soil, surface water, sediment, and subsurface systems to evaluate spatial and temporal patterns, exposure to environmental stressors/pollutants;
2. Identify, quantify, and predict the physical, chemical, biological and biochemical behavior of stressors, including characterization of their sources, transformations pathways and other factors that determine stressor exposure to humans and ecosystems across multiple media
3. Characterize the ecological and human receptors potentially impacted by stressors and pollutants;
4. Measure, predict, and apply data on environmental stressors to characterize exposure to humans and ecosystems;
5. Incorporate scientific understanding of environmental processes and ecosystem behavior, along with environmental exposure data, into predictive multimedia models to estimate exposure and to evaluate mitigation, restoration, prevention and management options;
6. Develop and implement receptor level exposure and dose models to provide risk assessors with better and more refined estimates of exposure and dose.
7. Develop chemical, physical, and biological measurement methods to identify and quantify environmental stressors and to characterize the environment;
8. Develop quality assurance methodologies for chemical, physical, radiological, and biological analyses;
9. Develop and apply geographical informational systems, remote sensing, photographic interpretation, information management technologies, software engineering technologies, computational chemistry, expert systems, and high performance computing to support the application of exposure and risk assessment tools;
10. Demonstrate, field test/evaluate, and transfer scientific information, measurement and quality assurance protocols, data bases, predictive exposure and risk assessment tools, and other innovative exposure assessment technologies, and provide environmental education materials to support Program Offices, Regions, State/Municipal/Tribal governments, and other Federal Agencies;
11. Provide technical support to Program Offices, Regions, State/Municipal/Tribal governments and other Federal Agencies to help in performing state-of-the-science exposure assessments of known certainty.

Research activities at NHEERL related to improving ecosystem risk assessment are designed to:

1. Develop and evaluate appropriate and meaningful indicators of ecological condition and develop associated criteria to characterize condition.
2. Develop and test approaches for monitoring frameworks that are integrated over multiple spatial and temporal scales to provide representative information about spatial extent of ecosystem resources, their current status (i.e., baseline condition) and how condition is changing through time.
3. Develop approaches to demonstrate relationships between effects on ecological condition and the relative magnitude of current stressors at multiple scales.

This field operations and methods manual represents a collaborative effort among principal investigators at NERL and NHEERL. The manual describes guidelines and standardized procedures for evaluating the biological integrity of surface waters of streams. It was developed to provide the Environmental Monitoring and Assessment Program (EMAP) with bioassessment methods for determining the status and monitoring trends of the environmental condition of freshwater streams. These bioassessment studies are carried out to assess biological criteria for the recognized beneficial uses of water, to monitor surface water quality, and to evaluate the health of the aquatic environment.

PREFACE

The Ecosystems Research Branch (ERB), Ecological Exposure Research Division, National Exposure Research Laboratory, U.S. Environmental Protection Agency - Cincinnati is responsible for field and laboratory exposure methods and ecological indicators that are used in assessing aquatic ecosystems. Research areas include the development, evaluation, validation, and standardization of Agency methods for the collection of biological field and laboratory data. These methods can be used by USEPA regional, enforcement, and research programs engaged in inland, estuarine, and marine water quality and permit compliance monitoring, and status and/or trends monitoring for the effects of impacts on aquatic organisms, including phytoplankton, zooplankton, periphyton, macrophyton, macroinvertebrates, and fish. The program addresses methods and techniques for sample collection; sample preparation; processing of structural and functional measures by using organism identification and enumeration; the measurement of biomass and benthic metabolism; the bioaccumulation and pathology of toxic substances; acute, chronic, and sediment toxicity; the computerization, analysis, and interpretation of biological data; and ecological assessments. ERB also includes field and laboratory support of the ecological biomarker research program and transfer of monitoring technology to the regions and state programs.

This document contains the EMAP-Surface Water field operations and bioassessment methods for evaluating the health and biological integrity of wadeable freshwater streams in the Western Pilot Study.

ABSTRACT

The methods and instructions for field operations presented in this manual for surveys of wadeable streams were initially developed and tested during 5 years of pilot and demonstration projects (1993 through 1997). These projects were conducted under the sponsorship of the U.S. Environmental Protection Agency and its collaborators through the Environmental Monitoring and Assessment Program (EMAP). This program focuses on evaluating ecological conditions on regional and national scales. This document describes procedures for collecting data, samples, and information about biotic assemblages, environmental measures, or attributes of indicators of stream ecosystem condition. The procedures presented in this manual were developed based on standard or accepted methods, modified as necessary to adapt them to EMAP sampling requirements for the Western Pilot Study. They are intended for use in field studies sponsored by EMAP, and related projects such as the USEPA Regional Environmental Monitoring and Assessment Program (R-EMAP), and the Temporally Integrated Monitoring of Ecosystems study (TIME). In addition to methodology, additional information on data management, safety and health, and other logistical aspects is integrated into the procedures and overall operational scenario. Procedures are described for collecting field measurement data and/or acceptable index samples for several response and stressor indicators, including water chemistry, physical habitat, benthic macroinvertebrate assemblages, aquatic vertebrate assemblages, fish tissue contaminants, and periphyton assemblages. The manual describes field implementation of these methods and the logistical foundation constructed during field projects. Flowcharts and other graphic aids provide overall summaries of specific field activities required to visit a stream site and collect data for these indicators. Tables give step-by-step protocol instructions. These figures and tables can be extracted and bound separately to make a convenient quick field reference for field teams. The manual also includes example field data forms for recording measurements and observations made in the field and sample tracking information. Checklists of all supplies and equipment needed for each field task are included to help ensure that these materials are available when required.

TABLE OF CONTENTS

Section	Page
NOTICE	ii
FOREWORD	iv
PREFACE	vii
ABSTRACT	viii
FIGURES	xiv
TABLES	xviii
ACKNOWLEDGMENTS	xxii
ACRONYMS, ABBREVIATIONS, AND MEASUREMENT UNITS	xxiii
1 INTRODUCTION	1
1.1 OVERVIEW OF EMAP-SURFACE WATERS	2
1.2 STREAM SAMPLING COMPONENTS OF EMAP-SURFACE WATERS	3
1.2.1 Mid-Atlantic Highlands Assessment Project	3
1.2.2 Mid-Atlantic Integrated Assessment Program	4
1.2.3 Temporal Integrated Monitoring of Ecosystems Project	4
1.2.4 Other Projects	5
1.2.5 Western Pilot Study	5
1.3 SUMMARY OF ECOLOGICAL INDICATORS	6
1.3.1 Water Chemistry	7
1.3.2 Physical Habitat	7
1.3.3 Periphyton Assemblage	8

TABLE OF CONTENTS (CONTINUED)

Section	Page
1.3.4 Benthic Macroinvertebrate Assemblage	9
1.3.5 Aquatic Vertebrate Assemblages	9
1.3.6 Fish Tissue Contaminants	10
1.4 OBJECTIVES AND SCOPE OF THE FIELD OPERATIONS MANUAL	11
1.5 QUALITY ASSURANCE	12
1.6 LITERATURE CITED	13
 2 OVERVIEW OF FIELD OPERATIONS	 19
2.1 DAILY OPERATIONAL SCENARIO	19
2.2 GUIDELINES FOR RECORDING DATA AND INFORMATION	20
2.3 SAFETY AND HEALTH	22
2.3.1 General Considerations	22
2.3.2 Safety Equipment and Facilities	28
2.3.3 Safety Guidelines for Field Operations	28
2.4 LITERATURE CITED	30
 3 BASE LOCATION ACTIVITIES	 33
3.1 ACTIVITIES BEFORE EACH STREAM VISIT	34
3.1.1 Confirming Site Access	34
3.1.2 Daily Sampling Itinerary	36
3.1.3 Instrument Inspections and Performance Tests	36
3.1.4 Preparation of Equipment and Supplies	40
3.2 ACTIVITIES AFTER EACH STREAM VISIT	45
3.2.1 Equipment Care	46
3.2.2 Sample Tracking, Packing, and Shipment	48
3.3 EQUIPMENT AND SUPPLIES	53
3.4 LITERATURE CITED	56

TABLE OF CONTENTS (CONTINUED)

Section	Page
4 INITIAL SITE PROCEDURES	57
4.1 SITE VERIFICATION ACTIVITIES	57
4.1.1 Locating the Index Site	57
4.1.2 Determining the Sampling Status of a Stream	58
4.1.3 Sampling During or After Rain Events	61
4.1.4 Site Photographs	61
4.2 LAYING OUT THE SAMPLING REACH	61
4.3 MODIFYING SAMPLE PROTOCOLS FOR HIGH OR LOW FLOWS	66
4.3.1 Dry and Intermittent Streams	66
4.3.2 Partial Boatable/Wadeable Sites	66
4.3.3 Braided Systems	68
4.4 EQUIPMENT AND SUPPLIES	68
4.5 LITERATURE CITED	69
5 WATER CHEMISTRY	73
5.1 SAMPLE COLLECTION	74
5.2 FIELD MEASUREMENTS	75
5.3 EQUIPMENT AND SUPPLIES	76
5.4 LITERATURE CITED	76
6 STREAM DISCHARGE	85
6.1 VELOCITY-AREA PROCEDURE	86
6.2 TIMED FILLING PROCEDURE	86
6.3 NEUTRALLY-BUOYANT OBJECT PROCEDURE	93
6.4 EQUIPMENT AND SUPPLIES	93
6.5 LITERATURE CITED	96
7 PHYSICAL HABITAT CHARACTERIZATION	97
7.1 COMPONENTS OF THE HABITAT CHARACTERIZATION	101
7.2 HABITAT SAMPLING LOCATIONS WITHIN THE SAMPLING REACH	103
7.3 LOGISTICS AND WORK FLOW	105
7.4 THALWEG PROFILE AND LARGE WOODY DEBRIS MEASUREMENTS	106
7.4.1 Thalweg Profile	106
7.4.2 Large Woody Debris Tally	115

TABLE OF CONTENTS (CONTINUED)

Section	Page
7.5 CHANNEL AND RIPARIAN MEASUREMENTS AT CROSS-SECTION TRANSECTS	115
7.5.1 Slope and Bearing	115
7.5.2 Substrate Size and Channel Dimensions	122
7.5.3 Bank Characteristics	127
7.5.4 Canopy Cover Measurements	130
7.5.5 Riparian Vegetation Structure	130
7.5.6 Instream Fish Cover, Algae, and Aquatic Macrophytes	136
7.5.7 Human Influence	138
7.5.8 Riparian "Legacy" Trees and Invasive Alien Plants	138
7.6 CHANNEL CONSTRAINT, DEBRIS TORRENTS, AND RECENT FLOODS ..	143
7.6.1 Channel Constraint	143
7.6.2 Debris Torrents and Recent Major Floods	146
7.7 EQUIPMENT AND SUPPLIES	149
7.8 LITERATURE CITED	149
8 PERIPHYTON	155
8.1 SAMPLE COLLECTION	156
8.2 PREPARATION OF LABORATORY SAMPLES	156
8.2.1 ID/Enumeration Sample	160
8.2.2 Acid/Alkaline Phosphatase Activity Sample	160
8.2.3 Chlorophyll Sample	161
8.2.4 Biomass Sample	164
8.3 EQUIPMENT AND SUPPLIES	165
8.4 LITERATURE CITED	165
9 SEDIMENT COMMUNITY METABOLISM	169
10 SEDIMENT TOXICITY	171

TABLE OF CONTENTS (CONTINUED)

Section	Page
11 BENTHIC MACROINVERTEBRATES	173
11.1 SAMPLE COLLECTION	175
11.1.1 Reach-Wide Sample	175
11.1.2 Targeted Riffle Sample	177
11.2 SAMPLE PROCESSING	185
11.3 EQUIPMENT AND SUPPLY CHECKLIST	187
11.4 LITERATURE CITED	187
12 AQUATIC VERTEBRATES	193
12.1 SAMPLE COLLECTION	194
12.1.1 Electrofishing	194
12.1.2 Seining	200
12.2 SAMPLE PROCESSING	200
12.2.1 Taxonomic Identification and Tally	200
12.2.2 External Examination and Length Measurements	204
12.2.3 Preparing Voucher Specimens	204
12.3 EQUIPMENT AND SUPPLIES	208
12.4 LITERATURE CITED	208
13 FISH TISSUE CONTAMINANTS	211
13.1 PREPARING SAMPLES FOR TISSUE CONTAMINANTS	211
13.2 EQUIPMENT AND SUPPLIES	213
14 RAPID HABITAT AND VISUAL STREAM ASSESSMENTS	221
14.1 RAPID HABITAT ASSESSMENT	222
14.2 VISUAL STREAM ASSESSMENT	229
14.3 EQUIPMENT AND SUPPLIES	235
14.4 LITERATURE CITED	235
15 FINAL SITE ACTIVITIES	241
Appendix	Page
A EQUIPMENT AND SUPPLY CHECKLISTS	A-1

FIGURES

Figure	Page
1-1. The geographic scope of the surface water component of the western pilot study, including the “special interest” study areas within each EPA Region.	7
2-1. General sequence of stream sampling activities	21
3-1. Activities conducted at base locations.	35
3-2. Performance test procedure for a dissolved oxygen meter.	38
3-3. Sample container labels.	46
3-4. Sample tracking form for unpreserved samples.	49
3-5. Sample tracking form for preserved samples.	50
3-6. Equipment and supply checklist for base location activities.	55
4-1. Verification Form (page 1).	60
4-2. Verification Form (page 2).	64
4-3. Sampling reach features.	65
4-4. Equipment and supplies checklist for initial site activities.	70
5-1. Completed sample labels for water chemistry.	76
5-2. Sample Collection Form (page 2), showing data recorded for water chemistry samples.	78
5-3. Channel Constraint and Field Measurement Form, showing data recorded for water chemistry.	80
5-4. Checklist of equipment and supplies for water chemistry.	83
6-1. Layout of channel cross-section for obtaining discharge data by the velocity-area procedure.	87
6-2. Stream Discharge Form, showing data recorded for all discharge measurement procedures.	90
6-3. Use of a portable weir in conjunction with a calibrated bucket to obtain an estimate of stream discharge.	91

FIGURES (CONTINUED)

Figure	Page
6-4. Equipment and supply checklist for stream discharge.	95
7-1. Sampling reach layout for physical habitat measurements (plan view).	104
7-2. Thalweg Profile and Woody Debris Form.	109
7-3. Large woody debris influence zones.	117
7-4. Channel slope and bearing measurements.	119
7-5. Slope and Bearing Form.	121
7-6. Substrate sampling cross-section.	124
7-7. Channel/Riparian Cross-section and Thalweg Profile Form.	126
7-8. Schematic showing bankfull channel and incision for channels.	129
7-9. Schematic of modified convex spherical canopy densiometer.	131
7-10. Boundaries for visual estimation of riparian vegetation, fish cover, and human influences.	134
7-11. Riparian "Legacy" Tree and Invasive Alien Plant Form (Page 1).	142
7-12. Channel Constraint and Field Chemistry Form, showing data for channel constraint	145
7-13. Torrent Evidence Assessment Form.	148
7-14. Checklist of equipment and supplies for physical habitat.	150
8-1. Index sampling design for periphyton.	157
8-2. Sample Collection Form (page1) showing data recorded for periphyton samples. .	159
8-3. Completed set of periphyton sample labels.	161
8-4. Filtration apparatus for preparing chlorophyll and biomass subsamples for periphyton.	164
8-5. Checklist of equipment and supplies for periphyton.	166
11-1. Modified D-frame kick net.	175
11-2. Index sampling design for benthic macroinvertebrate reachwide sample.	176
11-3. Sample Collection Form (page 1), showing information for the reach-wide and targeted riffle benthic macroinvertebrate samples.	180
11-4. Index sampling design for benthic macroinvertebrate targeted riffle sample. . . .	181
11-5. Completed labels for benthic macroinvertebrate samples.	187
11-6. Blank labels for benthic invertebrate samples.	188
11-7. Equipment and supply checklist for benthic macroinvertebrates.	189

FIGURES (CONTINUED)

Figure	Page
12-1. Vertebrate Collection Form (page 1).	195
12-2. Completed voucher sample label and specimen bag tag for aquatic vertebrates.	208
12-3. Equipment and supplies checklist for aquatic vertebrates.	209
13-1. Vertebrate Collection Form showing information recorded for fish tissue samples.	214
13-2. Completed sample labels for fish tissue contaminants.	215
13-3. Equipment and supplies checklist for fish tissue contaminants.	216
14-1. Rapid Habitat Assessment Form for riffle/run prevalent streams (page 1).	227
14-2. Rapid Habitat Assessment Form for riffle/run prevalent streams (page 2).	228
14-3. Rapid Habitat Assessment Form for pool/glide prevalent streams (page 1).	230
14-4. Rapid Habitat Assessment Form for glide/pool prevalent streams (page 2).	231
14-5. Stream Assessment Form (page 1).	234
14-6. Stream Assessment Form (page 2).	236
14-7. Checklist of equipment and supplies required for rapid habitat and visual stream assessments.	237

TABLES

Table	Page
2-1. ESTIMATED TIMES AND DIVISION OF LABOR FOR FIELD ACTIVITIES	20
2-2. GUIDELINES FOR RECORDING FIELD DATA AND OTHER INFORMATION	23
2-3. GENERAL HEALTH AND SAFETY CONSIDERATIONS	27
2-4. GENERAL SAFETY GUIDELINES FOR FIELD OPERATIONS	29
3-1. SUMMARY OF CHANGES IN BASE LOCATION ACTIVITIES FOR THE EMAP-SW WESTERN PILOT STUDY	34
3-2. CHECKING THE CALIBRATION OF THE DISSOLVED OXYGEN METER	39
3-3. STOCK SOLUTIONS, USES, AND INSTRUCTIONS FOR PREPARATION	41
3-4. PERFORMANCE CHECK OF NEWER CONDUCTIVITY METERS	42
3-5. PERFORMANCE CHECK OF OLDER CONDUCTIVITY METERS	43
3-6. GENERAL PERFORMANCE CHECKS FOR CURRENT VELOCITY METERS	44
3-7. EQUIPMENT CARE AFTER EACH STREAM VISIT	47
3-8. GENERAL GUIDELINES FOR PACKING AND SHIPPING UNPRESERVED SAMPLES	52
3-9. GENERAL GUIDELINES FOR PACKING AND SHIPPING PRESERVED SAMPLES	54
4-1. SUMMARY OF CHANGES IN INITIAL SITE PROCEDURES FOR THE WESTERN PILOT STUDY	58
4-2. SITE VERIFICATION PROCEDURES	59
4-3. GUIDELINES TO DETERMINE THE INFLUENCE OF RAIN EVENTS	62
4-4. LAYING OUT THE SAMPLING REACH	63
4-5. MODIFICATIONS FOR INTERRUPTED STREAMS	67
4-6. MODIFICATIONS FOR BRAIDED STREAMS.	69
5-1. SUMMARY OF CHANGES IN WATER CHEMISTRY PROCEDURES FOR THE WESTERN PILOT STUDY	75
5-2. SAMPLE COLLECTION PROCEDURES FOR WATER CHEMISTRY	77

TABLES (CONTINUED)

Table	Page
5-3. PROCEDURES FOR STREAMSIDE AND IN SITU CHEMISTRY MEASUREMENTS	79
5-4. PROCEDURES FOR IN SITU MEASUREMENTS OF DISSOLVED OXYGEN, CONDUCTIVITY, AND TEMPERATURE USING A MULTI-FUNCTION METER ...	81
6-1. VELOCITY-AREA PROCEDURE FOR DETERMINING STREAM DISCHARGE ...	88
6-2. TIMED FILLING PROCEDURE FOR DETERMINING STREAM DISCHARGE	92
6-3. NEUTRALLY BUOYANT OBJECT PROCEDURE FOR DETERMINING STREAM DISCHARGE	94
7-1. SUMMARY OF PHYSICAL HABITAT PROTOCOL CHANGES FOR THE EMAP-SW WESTERN PILOT STUDY	100
7-2. COMPONENTS OF PHYSICAL HABITAT CHARACTERIZATION	102
7-3. THALWEG PROFILE PROCEDURE	107
7-4. CHANNEL UNIT AND POOL FORMING CATEGORIES	112
7-5. PROCEDURE FOR TALLYING LARGE WOODY DEBRIS	116
7-6. PROCEDURE FOR OBTAINING SLOPE AND BEARING DATA	120
7-7. SUBSTRATE MEASUREMENT PROCEDURE	125
7-8. PROCEDURE FOR MEASURING BANK CHARACTERISTICS	128
7-9. PROCEDURE FOR CANOPY COVER MEASUREMENTS	132
7-10. PROCEDURE FOR CHARACTERIZING RIPARIAN VEGETATION STRUCTURE	135
7-11. PROCEDURE FOR ESTIMATING INSTREAM FISH COVER	137
7-12. PROCEDURE FOR ESTIMATING HUMAN INFLUENCE	139
7-13. PROCEDURE FOR IDENTIFYING RIPARIAN LEGACY TREES AND ALIEN INVASIVE PLANT SPECIES	140
7-14. PROCEDURES FOR ASSESSING CHANNEL CONSTRAINT	144
8-1. SUMMARY OF CHANGES IN PERIPHYTON PROCEDURES FOR THE WESTERN PILOT STUDY	156
8-2. PROCEDURE FOR COLLECTING COMPOSITE INDEX SAMPLES OF PERIPHYTON	158

TABLES (CONTINUED)

Table	Page
8-3. PREPARATION OF ID/ENUMERATION SAMPLES AND ACID/ALKALINE PHOSPHATASE ACTIVITY SAMPLES FOR PERIPHYTON	162
8-4. PROCEDURE FOR PREPARING CHLOROPHYLL AND BIOMASS SAMPLES FOR PERIPHYTON	163
11-1. SUMMARY OF BENTHIC MACROINVERTEBRATE PROTOCOL CHANGES FOR THE EMAP-SW WESTERN PILOT STUDY	174
11-2. PROCEDURE TO COLLECT KICK NET SAMPLES FOR THE REACH-WIDE COMPOSITE SAMPLE	178
11-3. LOCATING SAMPLING POINTS FOR KICK NET SAMPLES: TARGETED RIFFLE SAMPLE	182
11-4. COLLECTING A KICK NET SAMPLE FROM WADEABLE STREAMS FOR THE TARGETED RIFFLE COMPOSITE SAMPLE	183
11-5. PROCEDURE FOR PREPARING COMPOSITE SAMPLES FOR BENTHIC MACROINVERTEBRATES	186
12-1. SUMMARY OF CHANGES IN AQUATIC VERTEBRATE PROCEDURES FOR THE WESTERN PILOT STUDY	194
12-2. BACKPACK ELECTROFISHING PROCEDURES	197
12-3. BANK/TOWED ELECTROFISHING PROCEDURES	199
12-4. SEINING PROCEDURES	201
12-5. PROCEDURE TO IDENTIFY, TALLY, AND EXAMINE AQUATIC VERTEBRATES	202
12-6. GUIDELINES AND PROCEDURES FOR PREPARING AQUATIC VERTEBRATE VOUCHER SPECIMENS	205
13-1. PROCEDURE TO PREPARE FISH TISSUE SAMPLES	212
14-1. DESCRIPTIONS OF PARAMETERS USED IN THE RAPID HABITAT ASSESSMENT OF STREAMS	223
14-2. PROCEDURE FOR CONDUCTING THE RAPID HABITAT ASSESSMENT	226
14-3. PROCEDURE FOR CONDUCTING THE FINAL VISUAL ASSESSMENT OF A STREAM	232

ACKNOWLEDGMENTS

Review comments from the following persons are gratefully acknowledged: J.L. Stoddard (U.S. EPA, Corvallis, OR), G. Hayslip and L. Herger (U.S. EPA, Seattle, WA), J. R. Baker (Lockheed-Martin Corp., Las Vegas, NV), D. K. Averill (Dynamac Inc., Corvallis, OR), S. Gwin (Dynamac Inc., Corvallis, OR), T. Angradi (U.S. EPA, Denver, CO), M. Munn (USGS, Tacoma, WA). I. Waite (USGS, Portland, OR), D. P. Larsen (U.S. EPA, Corvallis, OR)...

The efforts and dedication of numerous field personnel from various Federal, State, and private organizations in implementing these protocols and providing feedback for clarification and improvement are also recognized. M. Hails-Avery and H. Gronemyer (National Asian Pacific Center on Aging, Senior Environmental Employment Program, Corvallis, OR) assisted with preparing many of the figures. S. San Romani and R. Warnock (OAO Inc., Corvallis, OR) prepared the field data forms and labels.

ACRONYMS, ABBREVIATIONS, AND MEASUREMENT UNITS

Acronyms and Abbreviations

AFDM	Ash-free dry mass
APA	Acid/Alkaline Phosphatase Activity
BPJ	Best Professional Judgment
BOD	Biological Oxygen Demand
CENR	(White House) Committee on the Environment and Natural Resources
CFR	Code of Federal Regulations
dbh	Diameter at breast height
DC	Direct Current
DIC	Dissolved Inorganic Carbon
DLGs	Digital Line Graphs
DO	Dissolved oxygen
EERD	Ecological Exposure Research Division
EMAP	Environmental Monitoring and Assessment Program
EMAP-SW	Environmental Monitoring and Assessment Program-Surface Waters Resource Group
EMAP-WP	Environmental Monitoring and Assessment Program- Western Pilot study
EPA	U.S. Environmental Protection Agency
ERB	Ecosystems Research Branch
GPS	Global Positioning System
ID	identification
LWD	Large Woody Debris
MAHA	Mid-Atlantic Highlands Assessment
MAIA	Mid-Atlantic Integrated Assessment
NAWQA	National Water-Quality Assessment Program
NERL	National Exposure Research Laboratory
NHEERL	National Health and Environmental Effects Research Laboratory
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
P-Hab	physical habitat
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RBP	(EPA) Rapid Bioassessment Protocol
R-EMAP	Regional Environmental Monitoring and Assessment Program
SL	Standard length
SOP	Standard Operating Procedure

ACRONYMS, ABBREVIATIONS, AND MEASUREMENT UNITS (CONTINUED)

Acronyms and Abbreviations (continued)

TIME	Temporally Integrated Monitoring of Ecosystems
TL	Total length
USGS	United States Geological Survey
WED	Western Ecology Division
YOY	young of year
YSI	Yellow Springs Instrument system

Measurement Units

amps	amperes
cm	centimeter
ft	foot
gal	gallon
ha	hectare
Hz	Hertz
in	inches
L	liter
m	meter
m ²	square meters
mg/L	milligram per liter
mm	millimeter
μm	micrometer
μS/cm	microsiemens per centimeter
mS/cm	millisiemens per centimeter
msec	millisecond
ppm	parts per million
psi	pounds per square inch
V	volts
VA	volt-ampere